OUTCROP

Newsletter of the Rocky Mountain Association of Geologists

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Lead Story

CREST Experiment Probes the Roots and Geologic History of the Colorado Rockies

By R. Aster, J. MacCarthy, Matt Heizler, and Shari Kelley (New Mexico Tech), K. Karlstrom and L. Crossey (University of New Mexico), Ken Dueker (University of Wyoming), and the CREST Team

Introduction:

General Tectonic Setting of the Colorado Rockies. *The Colorado Rockies are the climax of an enigma. They present a major young mountain range located approximately 1000 km from the nearest plate boundary (the San Andreas fault, which separates the North American and Pacific plates). In broad global tectonic context, the Colorado Rockies occupy the easternmost extent of the deformed western United States, an unusually broad tectonically active transition zone lying between the San Andreas Fault system and the stable central and eastern parts of our continent (Figure 2).*

The fundamental mechanism for the initial uplift of the Colorado Rockies is widely believed to be low-angle subduction of the Farallon plate during the Laramide Orogeny between approximately 75 and 50 million years ago. Because the oceanic slab was subducting at a low angle, it transmitted sufficient forces to the shallow crust and mantle (the lithosphere) to create great Laramide thrust structures as far east as the Black Hills of South Dakota. Ancillary evidence for low-angle subduction during the Laramie can be found in a paucity (but not total absence) of volcanic deposits during this period, consistent with a cold slab running along the base of a cool lithosphere. The subducting oceanic slab also lost its volatiles to the overlying continent, adding buoyancy and driving uplift of the western part of the North American plate.

However, the Laramide Orogeny was just the first act in a three-act play that has shaped the rugged topography of the western U.S. The second act began about 35 million years ago when the strike-slip San Andreas Fault system began to form and the Pacific-North America plate boundary transitioned from compressive subduction to the present strike-slip system. This transition had two dramatic effects on western North America. First, the stress across this vast region relaxed and compressively thickened Laramide lithosphere began to gravitationally relax. Dramatic results of this extension include the Great Basin and the Rio Grande rift. Second, the sinking of the trailing edge of the Farallon slab permitted mantle upwelling of underlying asthenosphere to heat the previous slab-cooled lower lithosphere that once resided above the subducting slab. The combination of upwelling mantle, increasingly extensional tectonics, and hydrated uppermost mantle was literally explosive, producing vast volcanism across the western United States. This post-Laramide "ignimbrite flare-up" included a San Juan Mountains super-volcano that erupted from multiple calderas 35-25 million years ago. This is one of the largest recognized volcanic complexes in the global geological record; the estimated eruptive volume of the San Juan La Garita Caldera complex is as large as 5000 cubic kilometers. The third act of the play, occurring during the last several million years, involves continued interactions between the North American plate and the underlying flowing mantle. These interactions include mantle plumes like the one under Yellowstone, continued volcanism like the Jemez volcano in New Mexico, and ongoing uplifts such

as the southern Sierra Nevada Mountains resulting from the upward flow of buoyant asthenospheric mantle replacing downward sinking of parts of the plate. Such upwellings of magma, heat, and fluid may be taking advantage of zones of plate weakness, providing glimpses of how old continental features influence young tectonic expressions. In addition to these tectonic and volcanic processes, the Rockies that we see today have, finally, been heavily sculpted by water and glacial erosion, most notably during the last 3 Ma as climate cooled.

The CREST Project. A major new science effort, CREST (Colorado Rockies Experiment and Seismic Transects), recently begun, is designed to help answer questions about how mantle processes beneath the Colorado Rocky Mountains have influenced their tectonic history. We are currently collecting and analyzing seismic, geochronologic, geochemical, and topographic data to study Earth's crust and mantle in the region. A key aspect of this work is to understand when and why changes in buoyancy forces and dynamic mantle convection forces have occurred since the end of Laramide subduction, as well as to understand current mantle dynamics. CREST was partially motivated by the prior discovery of a poorly resolved low velocity mantle seismic anomaly underlying the central Colorado Rockies, which we call the Aspen Anomaly (Figure 1; Figure 2). The Aspen Anomaly lies somewhere between the uppermost mantle and, perhaps, as deep as many hundreds of kilometers. It is part of a collection of major upper mantle velocity anomalies beneath the western United States that include Yellowstone (recently confirmed to be a mantle plume extending at least 600 km into the mantle) and the Rio Grande Rift-Jemez region (which is largely limited to the uppermost 300 km of the mantle). Testable hypotheses regarding the nature of the Aspen Anomaly tend to involve entangled processes that are difficult to isolate. It may be a region of broad scale mantle upflow associated with global convective flow: the flow pressures dynamically raising and continuing to support the Rockies today. Alternatively, the Aspen Anomaly may manifest hydrated lower lithosphere associated with

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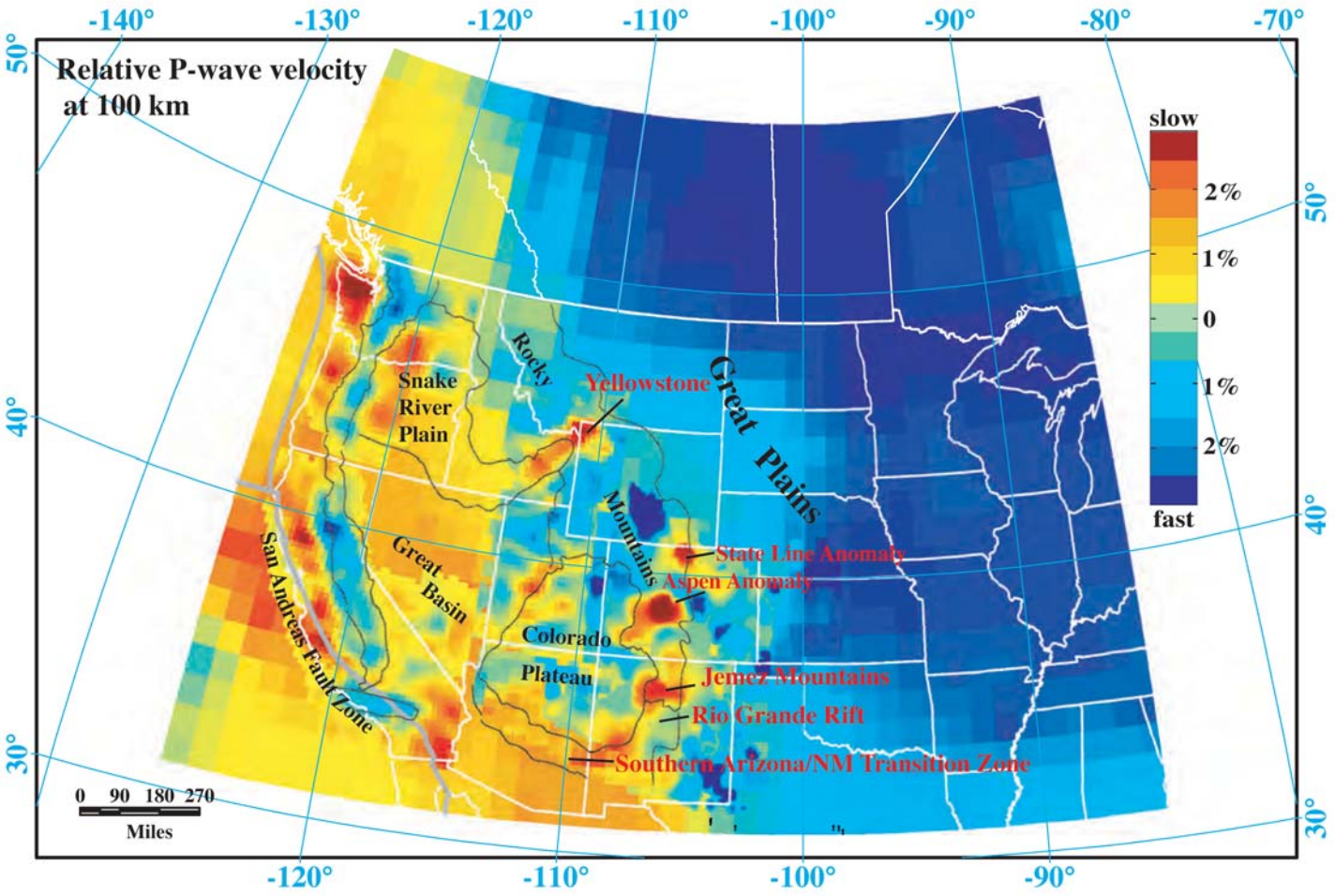

Figure 1. Western United States P-wave seismic velocity estimated at a depth of 100 km (c/o Ken Dueker; after Humphreys et al., 2003). Major low velocity anomalies in beneath the Rocky Mountain Region are labeled. CREST is focusing on the nature and influence of the presently poorly resolved Aspen Anomaly beneath the Colorado Rockies. CREST, EarthScope USArray, and other ongoing experiments are presently making dramatic strides in improving the resolution and accuracy of such mantle maps.

the Colorado Mineral Belt, which is a Proterozoic lithosphere-scale zone of weakness that likely originated at the time of continental accretion. Ancient architectural sutures within the continents are known to widely influence recent and present-day tectonics and volcanism (the Jemez Lineament in northwestern New Mexico is a prominent example). Emerging evidence that the high Rockies above the Aspen Anomaly may be tectonically active and currently uplifting includes active degassing of deeply derived gases rich in CO_2 and with high $^3He/^4He$ ratios that are found in most of the region's hot springs. Because ^3He represents escaping primordial gases that are a relic of planetary accretion, high $^3He/^4He$ ratios are a clear signature of volatile connections between the mantle and the surface.

CREST is taking place during a revolutionary period in seismic imaging that seeks to clarify how the North American continent is and has been shaped by mantle processes. Advances in portable seismographic instrumentation during the past 20 years have now made it possible for researchers to deploy arrays of up to thousands of state-of-the-art seismic recorders anywhere on the solid surface of the planet. In parallel with this revolution in instrumentation, a variety of innovative techniques have been developed to form detailed seismic images. Generally, these imaging methods are of two types: 1) we can look for seismic layering that shows up as velocity discontinuities (for example the Moho discontinuity at the base of the continental crust, a zone of interesting complexity in the Rockies) and 2) we can create tomograms (analogous to CAT scans) that reveal bulk mantle seismic velocity structure (for example the low velocity domain of the Aspen

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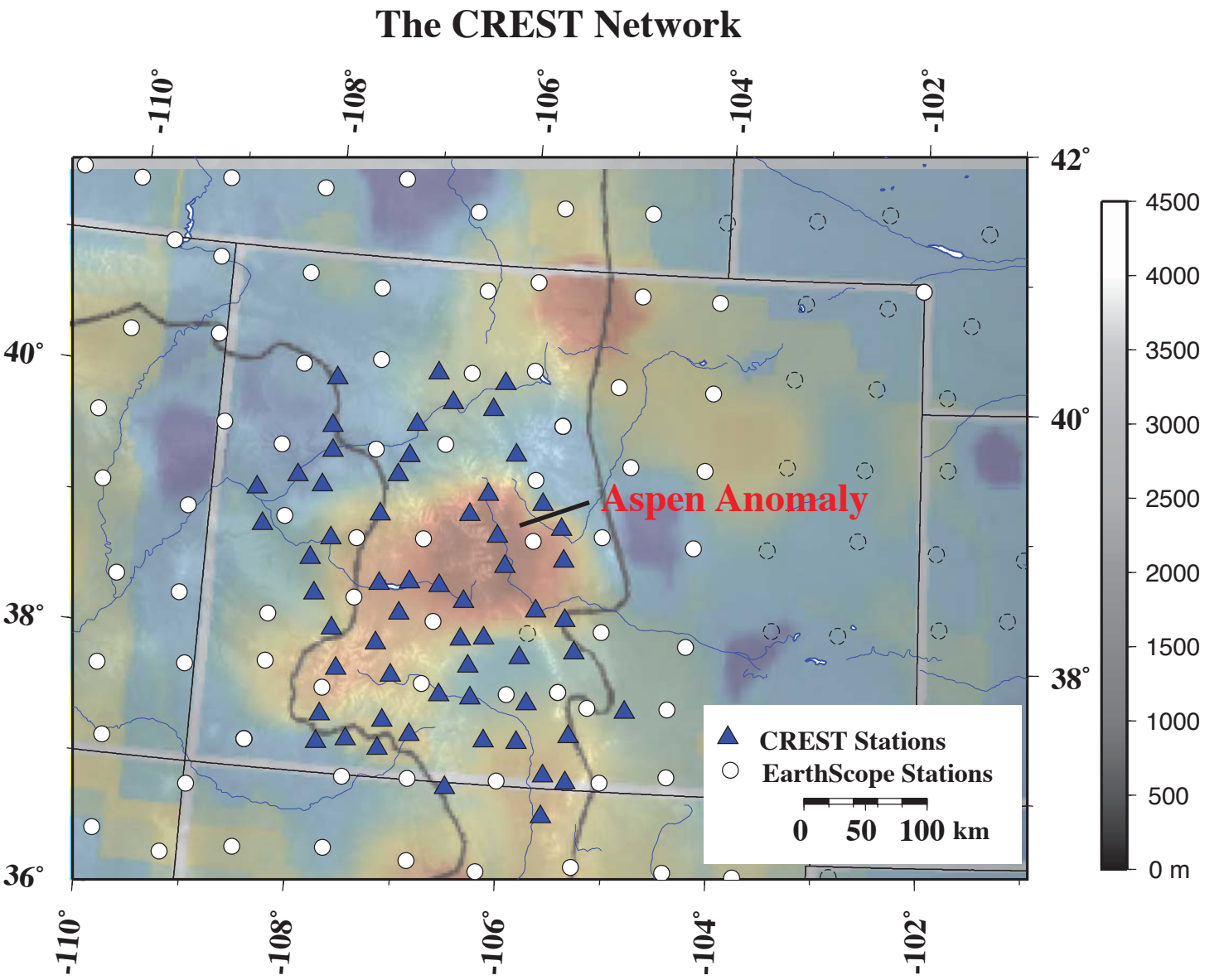

Figure 2. Close-up view of the topography and underlying mantle velocity structure at 100 km (from Figure 1), superimposed on gray-scale topography. Note the geographic association of the Aspen Anomaly with the high Rockies. Symbols show extent of existing or planed (dashed) seismograph stations.

Anomaly). Much of this imaging is done by recording how long it takes seismic waves to reach a given instrument from large earthquakes that occur in Indonesia, South America, and elsewhere around the globe. The distribution of global earthquake sources, as well as use of ambient noise imaging techniques; typically make it possible to form state-of-the art images of mantle structure after about a year and a half of continuous seismic "listening."

A large number of studies in the western United States and elsewhere during recent years have abundantly demonstrated that strong mechanical, volcanic, and geochemical coupling exists between deep crustal and mantle processes such as extension, lower crustal eclogitic delamination, and small-scale convection and upper-crustal tectonics. Partially driven by these remarkable observations of dynamism at the lithosphere-asthenosphere scale, EarthScope, a vast deployment of geophysical instrumentation, including GPS and seismometery across the United States was initiated in 2003. EarthScope will probe the deep structure of the entire conterminous U.S. with a 2000 station moving network of seismographic stations, dubbed USArray, through 2013, with a subsequent deployment planned for

Alaska. At present, USArray is deployed between the northern Rockies and the southwestern U.S., and CREST has recently complemented this seismograph deployment with an additional 59 stations (Figure 3) specifically focused on the region of the Aspen Anomaly. The combined USArray/CREST instrumentation constitutes one of the largest and densest seismic arrays currently deployed on the planet.

CREST will produce new 3-d images of the present Rockies. However, the fourth dimension is time. In imaging the state of the lithosphere, we also need to understand the rich prior history of North America. An important CREST component is a new suite of geochronology measurements designed to clarify patterns of Cenozoic magmatism and refine the timing of basaltic volcanism. This is being carried out with 40Ar/39Ar dating, focusing on a wide distribution of Laramide-age plutons within the Colorado Mineral Belt. The timing of uplift and erosion is being explored using samples collected from key locales throughout the study area via apatite fission track and the (U+Th)/He thermochronology methods which measure rock cooling histories related to exhumation. Additional key constraints on uplift history are being gathered from incision rate estimates derived from drainage profiles in the major river systems and other topographic constraints.

CREST will ultimately produce, we expect, a newly clarified understanding and level of geodynamic modeling of the current tectonic forces and processes of the Colorado Rocky Mountains, and their ties to deep Earth processes. We also hope that this will significantly enlighten our understanding of the formation and evolution of this region. During the past decade much has been learned, and many further questions have arisen, about the complex interactions between continental history and structure and today's active tectonics. The Rockies are a key locality to study these interactions, because they represent a region where coupling between old structures (even those dating back to the Proterozoic) and recent tectonics are strong. As such, the region is a natural laboratory to help us not only better understand one of America's iconic scenic landscapes, but also to inform global understanding of plate tectonics and the histories of the continents. The enigma of the Colorado Rockies is that they are a major mountain range over 1000 km from the plate boundary. The resolution of this enigma is coming from a better realization that the mountains are a manifestation of a wide deforming plate margin domain that is strongly coupled to deep mantle processes, and demonstrates that critical plate boundary processes exist not only at the edges, but also at the bases of moving plates.

Figure 3. Michael Johnson (New Mexico Tech IRIS PASSCAL Instrument Center) installing a CREST seismograph near Silverton, Colorado, in August 2008.

Acknowledgments

CREST is supported by the National Science Foundation Continental Dynamics Program under award 0607693. We thank the IRIS PASSCAL Instrument Center at New Mexico Tech for facility support and field assistance. Data collected will be available through the IRIS Data Management Center. The facilities of the IRIS Consortium are supported by the National Science Foundation under Cooperative Agreement EAR-0552316, the NSF Office of Polar Programs and the DOE National Nuclear Security Administration. The CREST team includes Andres Aslan, Rick Aster, Clem Chase, Dave Coblentz, Laura Crossey, Ken Dueker, Lang Farmer, Matt Heizler, Eric Kirby, Eric Leonard, Colin Shaw, and Jolante van Wijk, and graduate students

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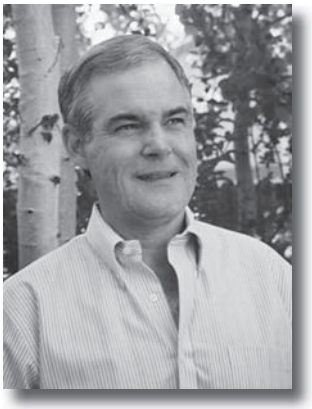

President's Column

by James Mullarkey

Off we go into another busy and exciting year

Well; a deep subject I know. Let's all pull together and get the year of 2009 off to a rousing start! My name is James Mullarkey, and I am a consulting geological engineer based in Littleton, Colorado. As RMAG's President for the next year, I would like to start off by saying that if you are aware of any needs or improvements for our organization, do not fail to let me know about them. As the society's incoming President, I would like to set two objectives; increasing energy savings, and increasing the pool of RMAG volunteers. I hope that each of you will consider contributing to the achievement of these goals.

Energy savings by Americans and the affluent global community can be, and needs to be part of the solution to alleviating the world's dependence on energy generated from hydrocarbons in their liquid and gas phases. Using a bridge analogy, borrowing freely from Dr. Scott Tinker, president of AAPG, and Mr. Boone T. Pickens, there needs to be a bridge to allow the United States and the world to move from the current dependence on oil and gas for the majority of energy generation to a much more diversified mix of sources of energy generation. Obviously, investment of some finite amount of time and the construction of multiple bridges will be necessary to allow the global community to achieve this. Energy savings is one bridge that any individual can contribute to building. I think that energy savings can be a part of a bridge that allows us to travel from the hydrocarbon dependence side of the river to the more diversified energy use side. Changing our habits is the more difficult path, as opposed to maintaining the status quo, but it is a path that needs to be followed for the greater good of our children and future generations.

Dr. Tinker has said when building a bridge that he usually starts with something he can accomplish, and this seems like a good idea to me. I plan to be able to say my family has installed new storm doors in a future column. So, paraphrasing Dr. Tinker in his speech at the Rocky Mountain Section meeting this past spring, let's brag about our energy saving accomplishments, and encourage others to do the same.

To start this off, without mentioning names, I'll do a little bragging for an RMAG member who lives in downtown Houston, and who was taking the lead back in 2006, and probably even before that, by being proactively environmentally conscious and being proud of that fact. This member was shining his light to help others see when he spoke with pride about the fact that he and his family put out only one trash can for the garbage pick up each week, besting their neighbors by a trash can or two, or three, all because they were consuming thoughtfully and recycling rather than consuming voraciously and tossing, filling trash cans and landfills willy-nilly. As you know, geologists are in general also environmentalists, with a long term outlook so I am looking forward to hearing many tales that top this one.

Here is an energy saving fact for this month: A 52" LCD screen television uses 58% of the energy of a 50" plasma screen television, 667 kilowatthours per year (kWh/yr) versus 1,159 kWh/yr; reference: ConsumerReports, October 2008, p. 23, consumerreports.org .

With regard to the second objective, I would like to start with a volunteer initiative, as many have before me. Our new president, Mr. Obama, has a plan to expand national and community service programs and I am convinced RMAG's 2500 plus members can be a major subset of this larger group of American volunteers!

I think I would like to focus our volunteer plan around creating a list of volunteers along with specific areas of interest so that the RMAG office staff, committee chairs, and the RMAG board could use the list to fill volunteer opportunities as they come up, which is on a regular basis, monthly if not weekly. With the emergence and increasing participation by our younger members, the network meeting numbers have steadily increased during 2008, and we are looking forward to this

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RMAG November Board of Directors Meeting

By Nick Harris, Secretary
(geologistnick@yahoo.com)

While the 2009 Board will approve the RMAG budget for next year, the 2008 Board is responsible for preparing a preliminary budget. In our last meeting, we debated this preliminary budget and recommended one that is similar to the current year's budget. Although we noted concerns relating to the recent drop in oil prices, it is our judgment that RMAG is exposed to limited risk in major areas of expenditure, specifically symposia and short courses. Although one year's record doesn't necessarily translate to success in the following year, we have had a strong 2008 with substantial gains in membership, strong attendance at technical events, and a positive balance sheet. In 2009, RMAG will also receive significant income from the Rocky Mountain Section – AAPG meeting held last summer.

Progress was reported on several publications: the Paradox Basin guidebook should be published early next year; the Uinta Basin guidebook has received sufficient sponsorship to pay for the volume; and the Board approved a guidebook with a focus on structural geology applied to petroleum exploration for publication in 2011. Planning for technical events for 2009 is also well underway, including the 3D Seismic Symposium and the Fall Symposium on resource plays, and a variety of short courses. The first of these courses will be in January – a structural geology course by Don Stone. A pair of courses on Petra and Geographix will be offered in the spring. «

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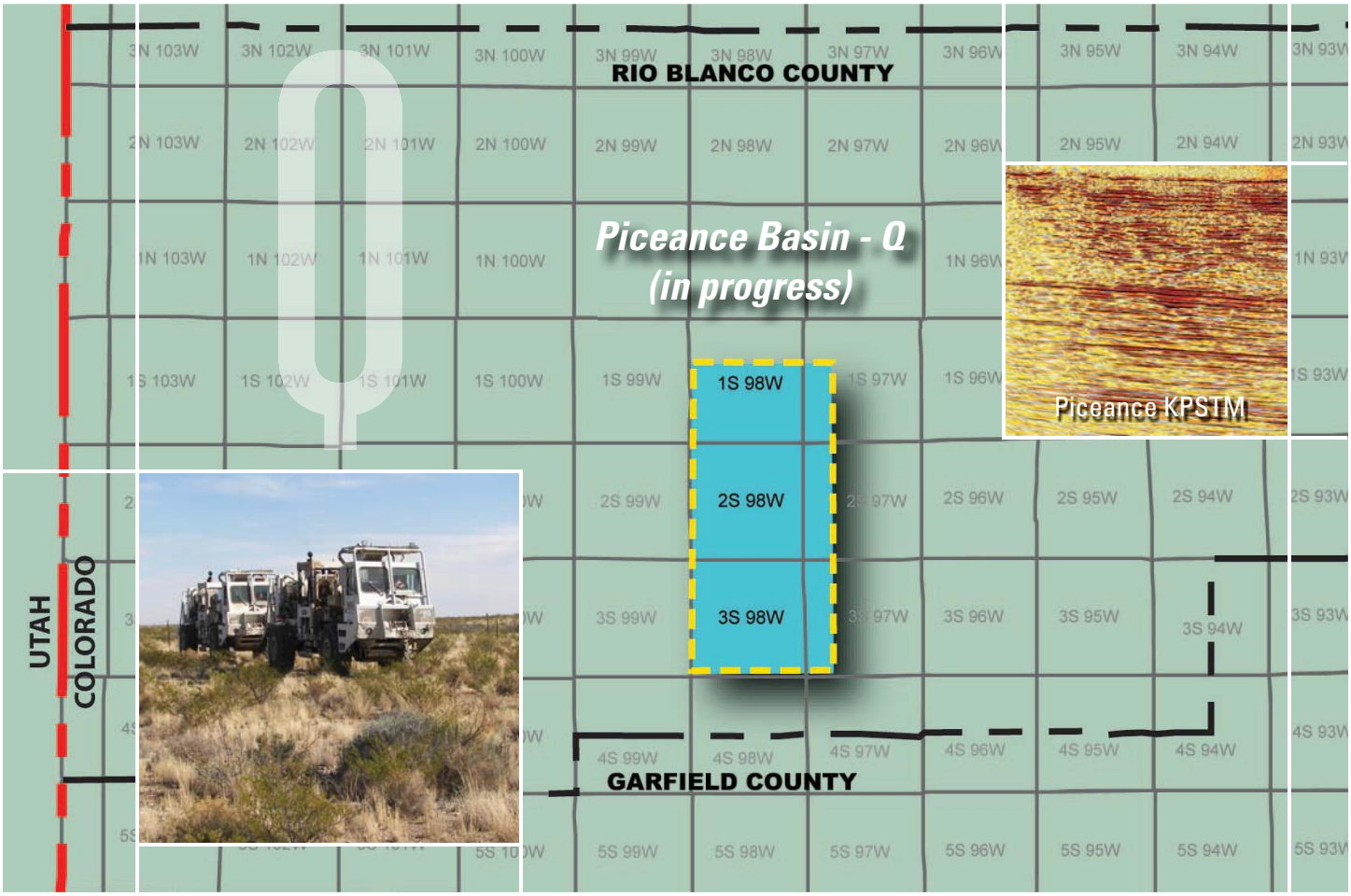

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In the Pipeline

January 9, 2009

DIPS Luncheon. Darrell Hoyer and Roger Young. "Seismic Petrophysics in Tight Gas Sands-A Piceance Basin, Mesa Verde Example." For reservations, contact Bob Zilinski at rezilin@aol.com or call 303-885-0615.

January 13, 2009

Desk and Derrick Club Luncheon. To make reservations email saundra.thompson@anadarko.com

January 16, 2009

RMAG Luncheon. Pete Stark. "Perspectives on U.S. Natural Gas."

January 20, 2009

DWLS Luncheon. Max Peeters. "Selection of Shaly Sand Methods and Parameters." Reserve through Sarah.Voight@Weatherford.com or 720-946-1374.

January 27, 2009

RMAG Short Course. Don Stone. "Review and Interpretation of Rocky Mountain Foreland Structures."

January 27, 2009

RMS-SEPM Luncheon. Lyn Canter, Orion Skinner, and Mark Sonnenfeld. "Facies and Mechanical Stratigraphy of the Middle Bakken, Mountrail County, North Dakota." For reservations, email Luncheons@rmssepm.org or call Steve Stancel at 720-929-6536.

January 28, 2009

Oilfield Christian Fellowship. To RSVP call Barb Burrell at 303-675-2602 or e-mail OCF-DenverChapter@pxd.com.

January 29, 2009

SIPES Luncheon. For reservations call the SIPES Denver Chapter message line at 303-730-2967, or leave a reservation via email to sipesdenver@yahoo.com.

February 5, 2009

RMAG Luncheon. Lou Mazzullo. "Applying Reservoir Models to Effective Exploration for Subtle and Unconventional Traps: Examples from the Permian Basin."

February 5-6, 2009

NAPE. See page 16 for more information.

February 9-13, 2009

AAPG Winter Education Conference. Houston, TX.

March 27, 2009

RMAG-DGS 3D Seismic Symposium. "Reveal the Rockies." See page 24 for more information. «

If you have any events that you would like to post in this column, please submit via email to Holly Sell at hsell@nobleenergyinc.com or to the RMAG office at rmagdenver@aol.com for consideration.

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RMAG Field Trip

Paradox Basin Fieldtrip participants raft the San Juan River with Wild Rivers Expeditions out of Bluff, Utah. Photo by Debra Higley-Feldman.

This photograph shows the shared west dipping limb of Raplee Anticline and the Mexican Hat Syncline about 1.5 miles upstream the village of Mexican Hat Utah, on the San Juan River. In the core of the anticline are the grey beds of the Upper Ismay interval and lower Honaker Trail Formation. These are overlain by the red deposits and marine limestones of the upper Honaker Trail Formation. The Permian Halgaito Formation forms the horizontal red strata on either side of the river. Photo by Jim Ligon.

Perspectives on U.S. Natural Gas

By Pete Stark, IHS Energy, Inc., January 16, 2009

On the positive side, innovative gas producers have "broken the code" to unlock productivity from shale gas and other unconventional reservoirs.

Three global mega-challenges have combined to create a perfect storm for world economies. Over the past 18 months focus on the climate change crisis gave way to soaring oil and gas prices and then passed on to the global financial crisis. The U.S. natural gas business has not been unscathed by this turmoil. Unfortunately, a welcomed surge in U.S. natural gas production emerged on the cusp of the economic recession and slumping energy demand. Good news for consumers is the fact that oil and gas prices have dropped 50% or more from first half 2008 highs. These factors, though, pose significant concerns for oil and gas producers and could signal a paradigm shift in U.S. energy markets and policies.

On the positive side, innovative gas producers have "broken the code" to unlock productivity from shale gas and other unconventional reservoirs. Success in the Barnett shale spread to the Fayetteville, Woodford, Haynesville and Marcellus shales with promising tests underway in other important shale source rocks. As a result of higher well productivities in these shales, U.S. average well peak production and EURs increased during 2007, breaking a 10-year decline in these parameters. Correspondingly, U.S. gas production capacity increased by some 4.5% during 2007 and about 9% during 2008. Moreover, recoverable gas resources may have increased by 500 Tcf or more during the past two years. This is good news for U.S. energy security and provides welcome flexibility for future energy planning. In the near term, the surge in gas productivity allowed the recovery of U.S. gas storage to more than 3.4 Tcf during November 2008 – assuring adequate gas for the 2008-09 winter heating season in spite of the fact that 5 Bcf per day of Gulf Coast gas production was curtailed by damage from Hurricane Ike.

There are several negative factors:

LUNCHEON RESERVATIONS AND INFORMATION

Luncheons will be held at the Marriott City Center at California and 17th St. Please check the event listing in the lobby for the room. People gather at 11:30 a.m., lunch is served at 12:00 noon, and the speaker presentation begins at about 12:20 p.m. The price of the luncheon is $30.00. Checks should be made payable to RMAG. No reservation is required for the talk only and the cost is $5.00. Please make your reservation prior to 10:30 a.m. on the Wednesday before the luncheon. Please Note: If you make a reservation and do not attend the luncheon, you will be billed for the luncheon. Cancellations are not guaranteed after 10:30 a.m. the Wednesday before the talk. You may send someone in your stead.

Your attendance is welcomed and encouraged. Bring a guest or new member!

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- Natural gas prices averaged about $9 per Mcf during 2008 but have slumped below $7 per Mcf and are unlikely to recover much during 2009. With Henry Hub gas at $7 per Mcf it is estimated that only about 35% of U.S. gas developments yield at least 10% ROR.
- Soaring Rockies gas production has exceeded export pipe capacity with resulting large discounts in gas prices and curtailed production.
- Huge new gas resources in the Ark-La-Tex region and Appalachian basin that have established pipelines and are close to the large consumers may reshape U.S. gas markets.
- Upstream costs continued to increase during 2008 adding to the squeeze on gas wellhead profits. High cost gas plays could suffer substantial drilling cutbacks during 2009.
- The change in administration is accompanied by increasing power for anti-oil and gas politicians. At this time it is not clear if their punitive attitudes toward oil and gas will prevail or of they will forge new clean energy policies that capitalize on secure domestic gas resources.

We will review these factors with respect to future directions for the U.S. gas business.

Applying Reservoir Models to Effective Exploration for Subtle and Unconventional Traps: Examples from the Permian Basin

By Louis J. Mazzullo, AAPG CPG, Mazzullo Energy Corp., Geological Consulting, Golden, Colorado, February 5, 2009

A multivariate approach to subsurface analysis should therefore include detailed sample evaluation that calibrates log responses to actual rock sequences.

Mapping and identification of reservoir facies is a critical first step to the understanding of reservoir development and trend analysis. The use of 3D seismic has benefitted these tasks greatly, enabling us to visualize the stratigraphic sequences within an exploration area to more refined levels than ever before. However, oftentimes our initial evaluation of a new exploration trend area or initial offset development involves picking formation tops and sequence boundaries using well log correlations, and, later on, trying to force these correlations to synthetic seismic ties. This type of approach at times could lead to seismic mis-ties, failure to accurately predict precise formation tops and reservoir trends, and missed opportunities in recognizing more subtle stratigraphic or combination traps. A multivariate approach to subsurface analysis should therefore include detailed sample evaluation that calibrates log responses to actual rock sequences. Several examples of correlation pitfalls from the Permian Basin are presented here. These include applications to the Permian Clear Fork of the Midland Basin, Upper Pennsylvanian Cisco-Canyon and Lower Pennsylvanian Atoka-Morrow sandstones (and associated Chesterian carbonates) in southeastern New Mexico, and the Siluro-Devonian and Ellenburger basin-wide. Each of these formations presents unique challenges to reservoir prediction because of their complex depositional and post-depositional histories.

Some of the problems related to misidentification of sequences or correlations from the Permian Basin have relevance to other basins. Well-to-well log correlations

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will often cross time units and lead to an improper interpretation of the juxtaposition of depositional environments. Log responses, especially gamma ray signatures, are often similar from sequence to sequence because of the repetitive nature of deposition in cyclic carbonate and clastic regimes. Karsted horizons often show higher gamma ray responses, and are reported on mudlogs as shales, but can be, in actuality, shale-supported karst and cave-fill facies with locally high interstitial porosity. Some of these karst-related facies can contribute substantial hydrocarbon reserves, but are generally overlooked as potential reservoir facies because they appear pessimistically shaly on well logs. There are many well-known structures where Atoka-Morrow sands lay unconformably upon lower Mississippian (Osagian) or older carbonates, absent the entire section in between. In order to effectively explore for the downthrown reservoir trends, it is essential to know the precise stratigraphic sequence and the degree to which Mississippian and younger beds were removed. But it is often difficult to tell the difference among the carbonate formations simply by correlating well logs. Simply mapping a structure on the Silurian-Devonian or Ellenburger is not enough to define a play; it is important to determine the diagenetic and stratigraphic attributes of these rocks below the conventional mapping horizons (e.g., Woodford Shale) in order to more accurately map a prospect and determine offset locations. Karsting is prevalent throughout the lower Paleozoic section, and further confuses the picture. Effective exploration for more subtle, yet lucrative, traps in all these rocks will require more "out-of -the-box" thinking as larger, structured fields are played out. «

President's Column

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influx of energy and ideas from these younger members. We especially want to hear from you, the sub 40 year olds, and get you and your colleagues more involved with the RMAG! I don't really consider myself as a "volunteering type" of person, but I have greatly expanded my horizons and contacts, meeting lots of enthusiastic, interesting people during my volunteer stints, mainly with the RMAG and the Boy Scouts of America. So even if you think that you are not a "volunteering type" of person maybe you should give it a try, I am guessing that it will be rewarding in a variety of ways, many unanticipated. And by the way, all you accredited, active RMAG volunteers, THANK YOU for all your work, and please keep on keepin' on.

I hope you will consider supporting RMAG and stimulating your whole brain, both right and left hemispheres, by registering for Don Stone's short course to be held Tuesday, January 27th. If you would like to volunteer to help with this or any other RMAG activities, please contact me or the RMAG office. There should be strong interest in Don's course "Review and Interpretation of Rocky Mountain Foreland Structures Exploring Descriptive, Kinematic and Dynamic Analyses, and Avoiding Common Pitfalls", based on the attendance at two 2008 RMAG Friday luncheon talks with structural geology themes (abstracts available at www.rmag.org). Don gave one talk on May 16th , "The wrench fault concept – revisited and fortified by modern seismic evidence" with about 150 in his attentive audience, and Dudley Bolyard gave a talk entitled "Strike-Slip Faults in the Colorado Rockies" on October 17th that was attended and enjoyed by about 100 folks. RMAG volunteer editors, Jerry Cuzzella and Connie Knight have initiated work on a future RMAG publication with a structural geology theme. As far as further opportunities in the 2009 continuing education realm, after the 15th annual 3-D symposium in March, in the second quarter of 2009 RMAG will present a one day short course offering tips to users of two geologic software packages, GeoGraphix and Petra, and the 3rd quarter will feature a one day symposium, chaired by RMAG volunteers Bruce Kelso and Bob Lamarre, highlighting Resource Plays.

In closing, did you hear why it is impossible to keep a secret in a bank? Too many tellers. That's all for this month, have a good month, and let's each take a step forward toward our 2009 objectives. «

Lead Story

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Jonathan MacCarthy, Andy Darling, Joshua Feldman, Rebecca Garcia, Steve Hansen, and Zhu Zhang. For more information, see www.ees.nmt.edu/Geop/CREST. More information on EarthScope can be found at www.earthscope.org.

References

Humphreys et al., How Laramide-age hydration of North American lithosphere by the Farallon slab controlled subsequent activity in the western United States, *Int. Geology. Rev.*, 45, 575-595, 2003. «

In Memoriam: Lorraine Druyff

Lorraine Druyff, age 59, passed away peacefully at home following a brave battle with cancer. She is survived by her husband Jim, daughter Jennifer (Brian), grandchildren Cooper and Grace, mother Edna, sister to Eileen (Don), Patricia, Mary, and Mike (Chris) as well as numerous nieces and nephews. Preceding her in death was her father Leo.

Lorraine was born and raised in Denver, Colorado to a large Irish-Catholic family. The family has many happy memories of spending time in the Colorado Mountains fishing and camping. Lorraine graduated from South High School with big dreams for the future. Lorraine was an accomplished cook and seamstress, which she learned while in 4-H.

As a young girl, Lorraine enjoyed the outdoors and swimming.

Her dreams carried her to sunny California where her career as a geologist began with her education at Cal State Long Beach. This was also the start of a long time love of the ocean and marine wildlife. Lorraine worked and supported herself through college. After graduating with a Bachelor of Science degree majoring in Geology, she returned to Denver and worked as a Petroleum Geologist for thirty years. Lorraine was an accomplished geologist and always in demand for her innovative skills as a petrographer and petrologist. She contributed to numerous professional papers and taught an industry course regarding petrophysical properties of cores and cuttings.

The family fondly remembers Lorraine's love of life and all things Irish. She loved to entertain and cook at home for family and friends. Thanksgiving was a special time, as Lorraine was always hosting the family feast, often cooking for thirty or more people that would come to the house looking for good food and laughter.

No year was complete without a trip to the beach with friends or family in tow. Some of Lorraine's favorite locations included Hawaii where she and Jim honeymooned. The family returned to Hawaii in February of 2008 to celebrate Jim and Lorraine's 25th wedding anniversary. Other beach vacations include Cozumel, Belize, and Bermuda where Jim and Lorraine traveled many times showing off the beautiful coral reefs to friends and family. It was in Mexico where Lorraine showed her adventurous spirit and took up scuba diving and was an avid snorkeler as well. Lorraine also traveled to Ireland to visit extended family. Her work also allowed her to travel to many places in the United States and to Romania and Switzerland.

Her hobbies included stained glass, gardening, reading, and numerous other artistic crafts.

The family recommends that instead of flowers you may contribute to one of Lorraine's charitable causes. Donations can be made to:

Denver Dumb Friends League (http://www.ddfl.org/tips.htm), American Cancer Society (http://www.cancer.org/docroot/home/index.asp) or Delores Project (http://www.thedeloresproject.org/) «


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The Mountain Geologist Best Paper Award for 2008

The RMAG is pleased to announce the winner of *The Mountain Geologist* Best Paper Award for 2008. The winning paper is "Stratigraphic and structural relations in the proximal Cutler Formation of the Paradox Basin: Implications for timing of movement on the Uncompahgre Front" by Katherine D. Moore, Gerilyn S. Soreghan, and Dustin E. Sweet.

This extremely well written and illustrated paper describes detailed facies and structural mapping of the proximal Cutler Formation of the Paradox Basin and the interpretation that the Precambrian-Cutler (Permo-Pennsylvanian) contact is a depositional onlap rather than a fault. Bedding patterns of the proximal Cutler indicate primary depositional dips associated with a Gilbert-type delta system, and the absence of syndepositional tectonic structures in the exposed Cutler in this area implies that thrusting on the subsurface Uncompahgre fault had ceased before deposition of the youngest Cutler strata.

The quality of papers published in the *Mountain Geologist* continues to be extremely high. Many wonderful papers were submitted this year making selecting one winner a very tough job. In reality, all the papers are winners, and we would like to thank all of the authors for publishing their outstanding work. If you haven't already, do yourself a favor and read not only the winning paper but all of the submissions.

Congratulations to Katherine, Gerilyn, and Dustin. «

The Best Paper Selection Committee

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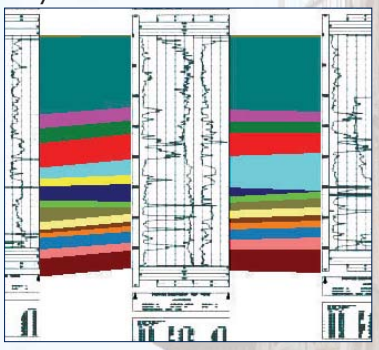

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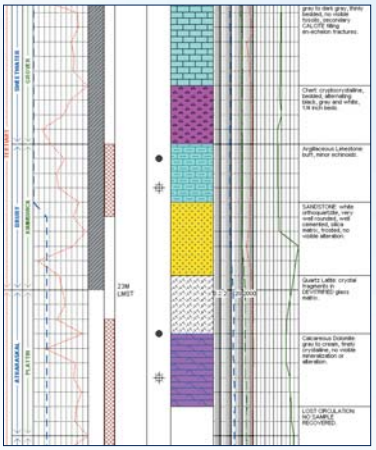

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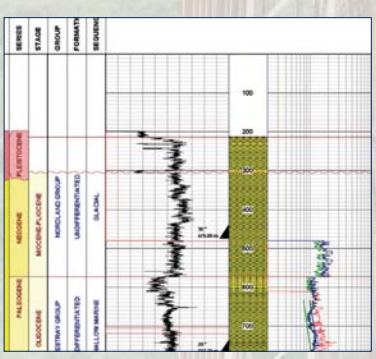

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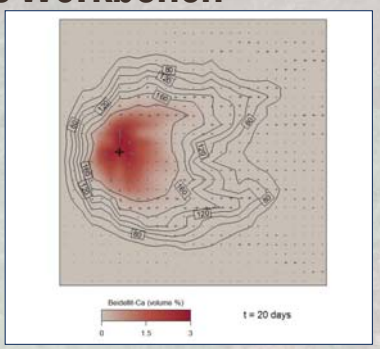

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NeoGeo: (n) a new member of the professional geoscience industry

By Cat Campbell

NeoGeos at the Marlowe's happy hour, from left, Katie Ransbottom, Becky Kowalski, Raffaello Sacerdoti, and Rick Nelson.

A new generation of geoscientists is steadily making its way into the industry allowing for new and unique networking and idea exchange opportunities. RMAG, in response to this flux of recently graduated professionals, created an extension known as the NeoGeos. The first formal meeting of this group took place on September 10th, at Earls, and was greeted with success! Leah Crosier, the contact for the NeoGeos says, "People enjoyed getting to catch up with their former classmates, colleagues and friends."

This new branch of RMAG joins Next Generation Landmen from DAPL, Young Professionals of SPE, from SPE, and groups from DGS and COPAS in the overall Next Generation Oil and Gas Professionals group, whose objectives include interdisciplinary outreach and networking events designed to create an active core of young professionals who will someday be the leaders of our industry. A happy hour event was held by the larger group on November 13, with over 300 young professionals in attendance.

If you are new to the industry and are interested in becoming part of this group or just want to learn more, please contact Leah Crosier at leah@petro-fs.com or Alexandra Fleming at Alexandra.Fleming@whiting.com. Also, sponsorship opportunities exist if your company would like to take part in this growing community! Several happy hours and other events including volunteering projects are planned for 2009. «

The Rocky Mountain Association of Geologists Presents

Review and Interpretation of Rocky Mountain Foreland Structures

Exploring Descriptive, Kinematic and Dynamic Analyses with Simple Tools, Models and Methodologies, and Avoiding Common Pitfalls

by Donald S. Stone

Tuesday, January 27, 2009 at the Marriott Hotel, Downtown Denver
Registration begins at 7:15 a.m., Course starts at 8:00 a.m.

Registration fee includes course notes, continental breakfast, refreshment breaks, and an end of event social hour.

REGISTRATION FORM

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___Registration fee AFTER December 31, 2008 for BOTH Members & Non-Members $170.00 $ _____
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No cancellations or refunds after December 31, 2008 **Total enclosed $ _____**

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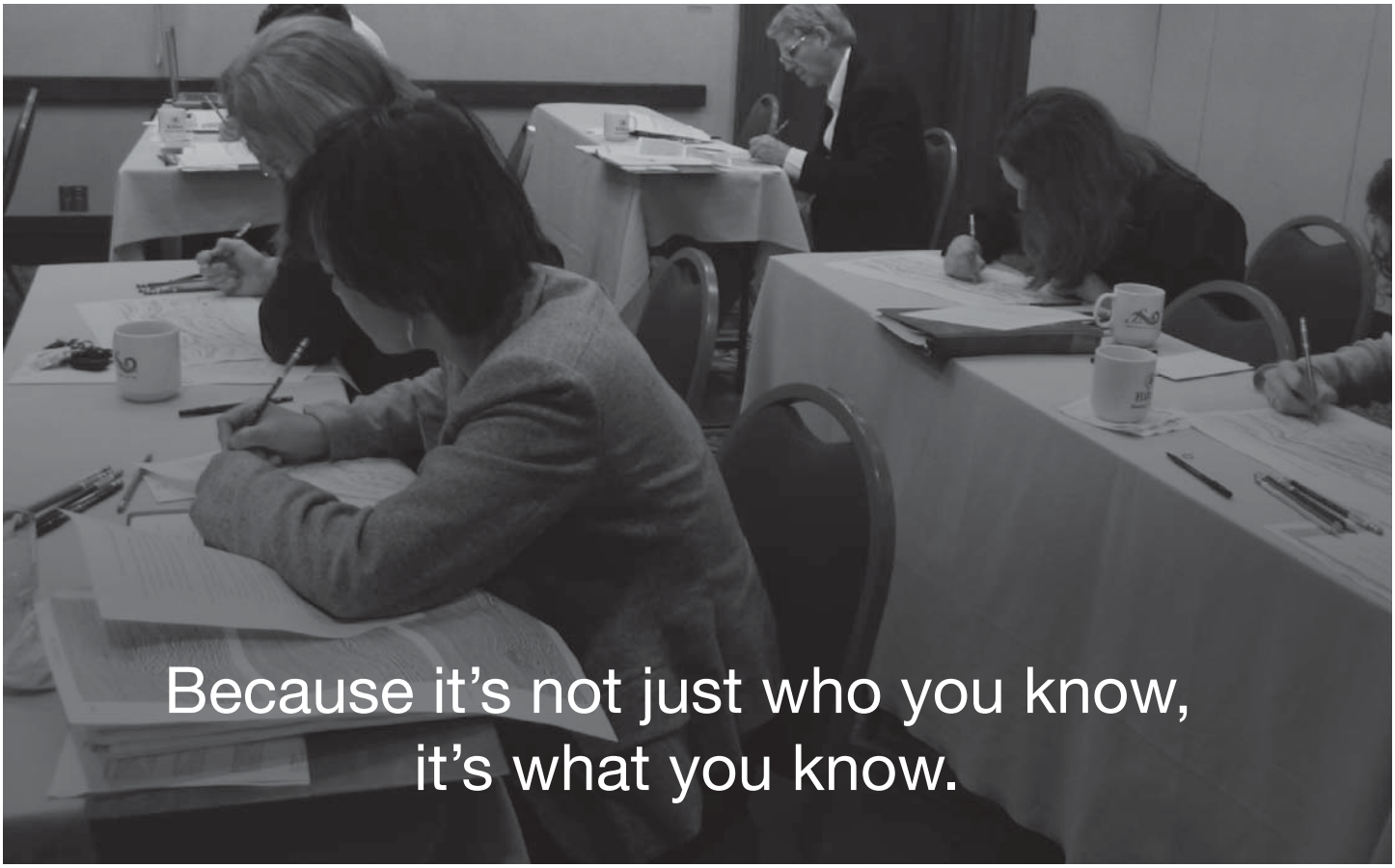

New Members

Welcome to New Members

Todd Peters

Todd Peters is a Geoscience Technical Coordinator for Pioneer Natural resources located in Denver, CO.

Jennifer Walker

Jennifer Walker is a Geologist for Encana Oil and Gas located in Denver, CO.

Laura Pommer

Laura Pommer is a Geoscientist for Williams Company in Denver, CO.

Colin O'Farrell

Colin O'Farrell is a Geologist for Pioneer Natural Resources located in Denver, CO.

John Byrd

John Byrd is a Senior Geological Advisor for Hess Corporation located in Houston, TX.

Lyn Canter

Lyn Canter is a senior Sedimentologist for Whiting Petroleum located in Denver, CO.

Ryan Sincavage

Ryan Sincavage is an Instructor for the University of Colorado Denver located in Denver, CO.

Gary Gianniny

Gary Gianniny is an Associate Professor for the Department of Geosciences at Fort Lewis College located in Durango, CO.

Gary Newman

Gary Newman currently resides in Gig Harbor, WA.

Welcome to New Associates

Gwen Pech

Gwen Pech is a Senior Systems Administrator for TerraSpark Geosciences, L.P. located in Boulder, CO. «

Advertisers Index

January 2009

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
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18	19	20 DWLS Luncheon	21	22	23	24
25	26	27 RMAG Short Course RMS-SEPM Luncheon	28 Oilfield Christian Fellowship	29 SIPES Luncheon	30	31

Rocky Mountain Association of Geologists
820 16th Street, Suite 505
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